DOCUMENT RESUME

ED 264 123 SE 046 285

TITLE	Fish: Form and Function. Secondary Curriculum.
INSTITUTION	New England Aquarium, Boston, Mass.
PUB DATE	85
NOTE	36p.
AVAILABLE FROM	New England Aquarium, Central Wharf, Boston, MA 02110 ($3.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Animal Behavior; Animals; Experiential Learning; Field Instruction; *Field Trips; *Ichthyology; *Marine Biology; *Science Activities; Science Education; Science Teaching Centers; Secondary Education; *Secondary School Science
IDENTIFIERS	*Aquariums; *Fishes

ABSTRACT

The New England Aquarium Education Department offers a series of curriculum units and field trip guides for teachers of all grade levels on aquatic biology and ecology topics. Fish characteristics and behaviors are explained in this packet for secondary science teachers. Pre-trip materials include factsheets and worksheets on fish: (1) characteristics; (2) general anatomy; (3) senses; (4) coloration patterns; (5) shapes; (6) survival behaviors; and (7) external and internal anatomy. Forms for recording observations on fish behaviors and characteristics during an excursion are provided. Suggestions for post-trip activities are also given. This particular guide contains a floor plan of the New England Aquarium, a listing of aquatically oriented curriculum packets, and an explanation of the facility's teacher resources. (ML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

Fish: Form and Function

Secondary Curriculum

ED264123

SE 046 285

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Elizabeth Tayntor

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 8830

for teachers

Science comes alive for students when they visit the New England Aquarium. Animals and environments from around the world illustrate and support important concepts in aquatic biology and ecology.

All curriculum packages contain:

- information for teachers
- fact sheets and topics for discussion
- a floor plan of the New England Aquarium and hints on field-trip planning
- suggested activities, student worksheets and projects for field-trips and the classroom
- vocabulary and a bibliography

FISH: FORM AND FUNCTION, is about fishes and their adaptations for survival. Information sheets discuss characteristics common to all fishes, while emphasizing their tremendous diversity. Worksheets and Aquarium activities teach students to "read" fishes, that is to use colors and shapes as clues for predicting fish lifestyles and their adaptations for survival. As you and your students become experienced fishwatchers, you will learn to appreciate not only the beauty, but also the function, of form and color in the world of water.

The New England Aquarium's multi-media program, "FISHTALES", offers an exciting look at unusual fishes from around the world. This and other educational programs on a variety of topics can be scheduled for your group when you visit the Aquarium. Programs are FREE, but advance RESERVATIONS ARE REQUIRED. For more information , contact the Sales Office, (617)-742-8830.

We hope this curriculum unit will help to prepare you and your students for a visit to the New England Aquarium. Please take a few minutes to let us know if these curriuculum materials meet your needs. An evaluation form is enclosed for your comments.

If you have questions about this curriculum or any other Education Department offerings, please do not hesitate to call or write to us for more information.

Enjoy your visit,

Elizabeth Tayntor
Assistant Curator,
Education

Dr. Les Kaufman
Director,
Education

copyright for educational purposes only

teacher resources

CURRICULUM PACKETS:	These contain fact sheets, worksheets, and field trip activities. Request one for FREE when you make a reservation to visit. Additional copies are $3.
PRE-VISIT PASSES:	Teachers may visit the Aquarium FREE of charge to view our changing exhibits and plan field trip activities. Request your pre-visit pass from the Education Office.
EDUCATIONAL PROGRAMS:	See a Dolphin and Sea Lion Show and one of our Educational Programs when you visit. Programs are FREE. Advance reservations are required. Seating capacity is limited.
TEACHER WORKSHOPS:	Sharpen your knowledge of Aquarium animals and aquatic environments at a teacher workshop. Thursday afternoons, 4-6pm. once per month. Fees vary. For a complete schedule of topics, call the Education Office.
TRAVELING SLIDES:	Prepare students for a visit to the New England Aquarium with slides and a script that highlight many aquatic animals and habitats. Slide sets are loaned, as available, to groups with a field-trip reservation. A postage fee is required.
ANIMALS ON THE ROAD:	Combine a live animal program in the classroom with an Aquarium field trip for a mini-course on ocean life. Prices begin at $65 and vary depending on group size. Call the Education Office for a complete list of outreach offerings.
WHALE WATCH:	Take your students on an adventure to see whales in their natural habitat. For special group rates, call the Sales Office.
MASSACHUSETTS SCHOOLS:	Thanks to the generous support of the Mass Department of Education, all Mass students visting in organized groups are now FREE at the New England Aquarium. RESERVATIONS ARE REQUIRED. For more information call the Sales Office.
FOR MORE INFORMATION:	Call the Education Department, (617)-742-8830, or write c/o School Resources Coordinator.

copyright for educational purposes only

curriculum materials

To help you plan a field trip to the New England Aquarium, the Education Department has developed a series of curriculum packets. These units focus on popular Aquarium exhibits and important aquatic themes. Daily educational offerings support curriculum materials.

Curriculum packets include: 1) information to prepare your students for a visit to the New England Aquarium, 2) hints for planning a successful field trip, and 3) follow-up activities for the classroom.

Aquarium Exploration Kit, grades K-2	_____	$3.00 each
Tidepools: Edge of the Sea, grades K-6	_____	$3.00 each
Tidepool Information Sheets, grades 2-8 (set of eight fact sheets with illustrations for classroom study)	_____	$1.50 per set (10 or more, $1 per set)
Sharks, grades 3-6	_____	$3.00 each
Seals, grades 3-6	_____	$3.00 each
Aquarium Resource Kit, grades 6-8	_____	$3.00 each
Fish: Form and Function, grades 6-12	_____	$3.00 each
Inside the Giant Ocean Tank, grades 6-12	_____	$3.00 each
Whales of New England, grades 6-12 (whale watch curriculum)	_____	$3.00 each
Self-guided Tour of the Aquarium, high schools and universities (includes Teacher's Guide)	_____	$3.00 each
	_____	TOTAL

To order curriculum, send your name, address and name of school to:

New England Aquarium
Central Wharf
Boston, MA 02110
Attn: Education/Curriculum

Please include payment with your order. All checks should be made payable to the New England Aquarium. Please allow two weeks for delivery.

For more information on this and other Education Department programs, please call (617) 742-8830, or write to us.

copyright for educational purposes only

1

pre-trip activities

what is a fish?

What is a fish? That's a tough question to answer. With more than 25,000 species identified to date, and an average of 100 new species being discovered annually, fishes are an extremely diverse group of vertebrates. Beacause of their diversity, fishes live in almost all the waters of the earth: in the sub-freezing waters of the Antarctic Ocean and hot springs of 109 F; in mountain lakes, 3 miles high, and deep-sea trenches, 7 miles beneath the ocean's surface. Fishes range in size from pygmy gobies, only 1/3 of an inch long, to sixty-foot whale sharks weighing several tons. Most fishes swim, but some walk, while others fly and glide. A few fishes burrow like moles, others hibernate like bears. Some even spend part of their lives out of water and breathe air.

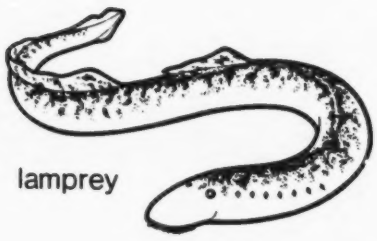
While they are collectively referred to as fishes, these aquatic vertebrates fall into not one, but three distinct classes:

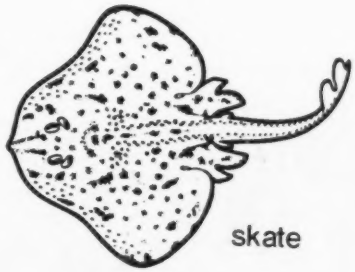
Agnatha (jawless fishes)- contains the lampreys, hagfishes, and a few species that lack jaws and have rounded sucking mouths. Some agnathans are parasites, others scavengers. Predating man by 480 million years, they are believed to be the first vertebrates that evolved.

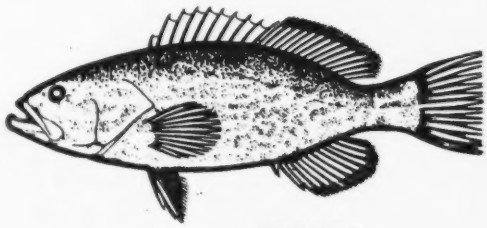
Chondrichthyes (cartilaginous fishes)- contains 600+ species of sharks, skates, rays, and chimeras. All of these fishes have jaws, but lack true bone.

Osteichthyes (bony fishes)- includes all other species of fishes. Osteichthyes is the most numerous class of vertebrates.

These three classes of fishes are as different from each other as they are from the birds, mammals, reptiles, and amphibian classes. Within each class of fishes, the tremendous diversity in size, shape, habitat and behaviors among individual species makes it nearly impossible to simply define the term fish.


lamprey


skate


grouper

copyright for educational purposes only

fish anatomy 1

A fish is a vertebrate with gills for breathing, fins (usually) for locomotion, scales (often) for protection, and a simple heart. These vertebrates are specially adapted to life in water.

GILLS

Most fishes exchange oxygen and carbon dioxide during respiration via gills. In many species, bony gill flaps or gill slits protect the delicate gill filaments. Some fishes have gills modified for feeding. Comb-like appendages called "gill rakers" strain plankton from the water as the fish swims.

HEART

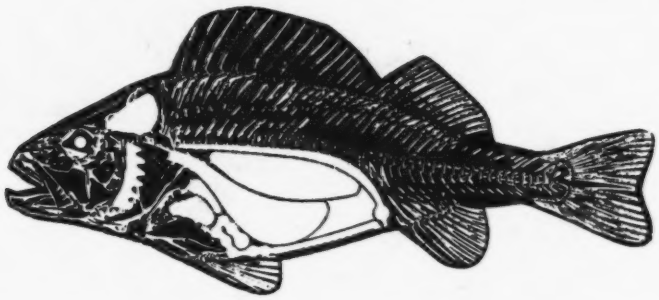
Fishes have a simple tube-like heart. Sometimes called a two-chambered heart, it actually has four chambers but they are not as well-divided as our own. Oxygen-rich blood entering a fish's heart fresh from the gills is diluted by oxygen-poor blood returning from other parts of the body. As a result, the fish heart is effective but not as efficient as ours. Through evolution, the simple heart found in fishes became the more advanced four-chambered organ now found in birds and mammals.

ARE FISHES COLD BLOODED?

Usually, yes. Most fishes are the same temperature as the water surrounding them. Some, however, have behavioral or physiological ways of controlling their body temperatures. Tuna, great white sharks and some other open ocean species maintain body temperatures higher than the surrounding waters with a specialized circulatory system that conserves heat. Some Arctic and Antarctic species can live at sub-freezing temperatures because they have natural anti-freeze, chemicals in their blood.

INTERNAL SKELETON

All fishes have backbones. Sharks, skates, rays and chimeras have skeletons and backbones of cartilage, but most fishes are "bony fishes". Their skeletons are made of true bone. The evolution of a rigid internal skeleton provided bony fishes with a new kind of structural support, one that gave them greater agility and greater freedom of movement. It was also an important step towards the evolution of vertebrates that could eventually walk on land.



copyright for educational purposes only

fish anatomy 2

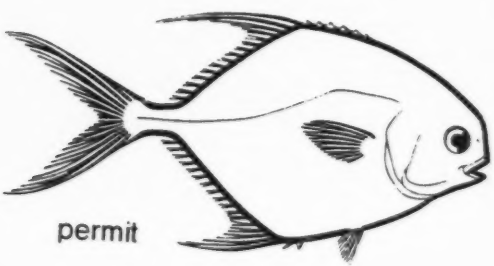
SWIM BLADDER

Most bony fishes have a gas-filled swim bladder located beneath the backbone. By adjusting the gas volume of this organ, a fish controls its buoyancy and can hang effortlessly at a desired depth in the water.

Sharks and other fishes do not have swim bladders, and most must swim constantly to avoid sinking. To compensate, sand tiger sharks seem to swallow air to increase their buoyancy. Other sharks have huge stores of liver oils that are lighter than water.

The swim bladder of bony fishes probably evolved from a primitive lung. A few species, such as the bowfin, still use the swim bladder to breathe. This organ also plays a role in sound production and amplification in many fishes.

FINS



permit

Fins help fishes move and provide swimming stability. Medial fins, such as the dorsal and anal fins, act like the keel of a boat. Paired fins, like the pectorals and pelvics, are used for turning and stopping. In many species the caudal fin, or tail, provides most forward movement and controls direction. Yet despite these generalities, different fishes use their fins in different ways. Their style of swimming also depends on how flexible their bodies are, their body shapes, and where they live.

SCALES

Most fishes have protective scales. Although the scales appear to be the outermost layer on the body, they are covered by a thin layer of skin and protective mucous. Bony fishes usually have thin, transparent scales. Sharks and rays have tooth-like scales called denticles, which give their skin a rough sandpaper texture.

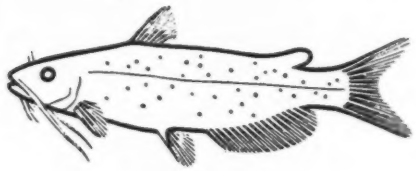
Scales may range in size from those of the common eel which are microscopic to those of the mahseer, an Indian fish with scales the size of a person's hand. Some fishes like the swordfish and sculpin do not have scales at all.

copyright for educational purposes only

fish senses 1

How do fishes sense the world around them? In addition to taste, smell, sight, touch, and hearing, fishes have other senses that take advantage of the unique properties of water.

TASTE



channel catfish

In fishes, taste buds are not confined to the mouth. They may also be found on the lips, snout, head, even all over the body. Sea robins, hakes, and other bottom-dwellers that probe the sea floor in search of food, have taste buds on long filamentous fins. Catfishes taste the bottom with fleshy whisker-like organs called barbels. Some freshwater fishes have taste buds on their gill arches and in their throats.

SMELL

Fishes have the equivalent of our nose in the form of nostrils, or nares. Jawless fishes have one nostril on top of the head; most fishes with jaws have paired nostrils. In sharks, the nostrils are on the underside of the snout. In bony fishes they are above the mouth or to the sides. Water flows in and out of these pits, and receptors detect odors.

While taste is a short-range sense that requires close contact, smell is more long-range. With smell, fishes can detect chemicals in dilute solutions even at great distances. They are sensitive to the faintest scent- just a few molecules are enough. Sensing differences in the concentration of chemicals on each side of its head, a shark uses its acute sense of smell to locate prey. This ability to sense a chemical gradient may be especially well-developed in the hammerhead shark because of the distance between its nostrils.

Smell also plays an important role in fish migration. As young salmon leave their native streams, they are imprinted with the unique odors of their home waters. Later, these odors are the cues that lead adults back to the same streams to spawn.

VISION

All vertebrate eyes are basically alike, but aquatic life has led to certain modifications in the eyes of fishes. Fishes do not shed tears. The water around them keeps the surface of their eyes moist and clean. And, because their eyes are always moist, most fishes lack true eyelids. In many bony fishes, the eye protudes slightly. These fishes see not only to the front but also to the sides and almost behind them. A fish eye lens on a camera creates the same wide-angle effect.

Visual acuity ranges from non-existent, as in blind cave-dwellers, to poor, as in conger eels, to excellent, as in trout, which can focus simultaneously on near and far objects. Some shallow water fishes can distinguish a wide range of colors and intensities. Fishes from deeper waters probably distinguish fewer colors, since most color is absorbed in the upper layers of the water column.

copyright for educational purposes only

fish senses 2

HEARING

Fishes lack external and middle ears, but their inner ear resembles ours and serves the same purposes of hearing and balance. Sound travels about 5 faster in water than in air so fishes can hear sounds from a distance more easily than land vertebrates. All fishes receive sound waves through their bodies. Minnows, catfishes, and their relatives have particulary acute hearing. In these fishes, each ear is linked by several small bones to the gas-filled swim bladder. As sound waves vibrate the swim bladder walls, the connecting bones amplify the sound and transmit it to the ears.

Otoliths, or ear stones, are a part of the fish's inner ear. These calcium deposits vary in shape from species to species and are often used in classification. By studying the growth rings on otoliths, scientists can also estimate a fish's age.

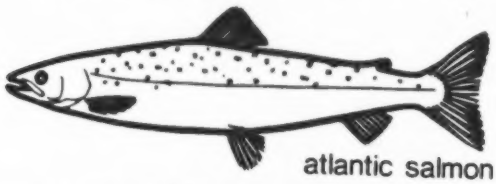
TOUCH

Fishes, like humans, have touch receptors scattered all over the body surface. Touch is primarily a short-distance sense.

LATERAL LINE

The lateral line is a unique sensory system found only in fishes and a few amphibians. It is used for long-distance touch perception. Receptors called neuromasts sense low frequency compression waves and vibrations in the water such as those caused by the movement of other animals. Neuromasts also sense vibrations reflected back from ojects. These help a fish to navigate and avoid obstacles.

Some fishes, including hagfishes and lampreys have individual neuromasts scattered over their bodies. In most fishes, the neuromasts lie in a fluid-filled canal just beneath the skin.



atlantic salmon

The lateral line is then visible as a long stripe running along each side of the fish's body. Pores, visible in the scales covering this line, lead into the fluid-filled canal just below the surface of the skin.

ELECTRORECEPTION

In addition to the lateral line pores, many fishes have pits on the surface of their skin that open into specialized electrical receptors. In sharks, these are known as the ampullae of Lorenzini, and are clearly visible on the snout and head of many species. With these electroreceptors sharks can detect minute electrical charges, and will locate live prey hidden in the sand by tuning in to the electrical impulses the prey emits.

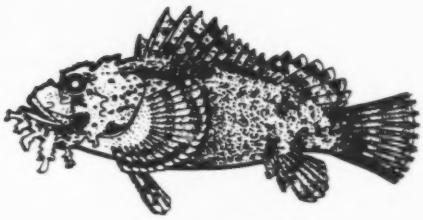
It is possible that electroreception helps sharks navigate across long distances. As a shark swims through the earth's magnetic field it induces an electrical current. When the shark changes direction, the intensity of the current changes, too. Sensing these changes in electrical current as it swims may give the shark an electromagnetic compass sense for long-range navigation.

copyright for educational purposes only

color codes 1

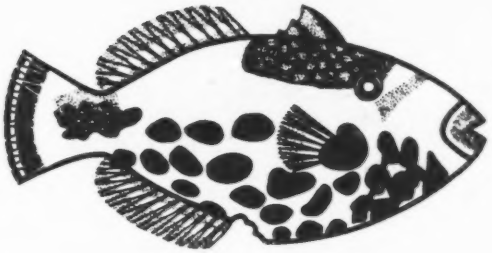
To the casual observer, the colors and patterns of fishes may look like the fanciful creations of an imaginative painter. Yet even the most unusual coloration in fishes helps them survive in particular environments. The observant fishwatcher can use fish colors as codes to learn more about fish habitats and lifestyles.

COLORS THAT HIDE



scorpion fish

CAMOUFLAGE coloration helps animals blend in with their surroundings. Flounder can change color and patterns instantly to match the ocean floor. Sea ravens and scorpionfishes add to their disguises with fleshy appendages that look like seaweeds on a rock.



clown triggerfish

Spots, stripes and patches of color help break up the typical outline of a fish. This DISRUPTIVE COLORATION is common in many reef fishes. The brilliant colors and patterns of triggerfishes, angelfishes, and butterflyfishes help hide them against the colorful backdrop of the coral reef.

alligator gar

Sharks, barracuda and many schooling fishes are camouflaged for life in open water. These fishes have dark backs and light bellies, a color pattern known as COUNTERSHADING. Viewed from above, their dark backs blend with the darkness of the deep ocean. From below, their light bellies blend with bright sunlit surface waters.

copyright for educational purposes only

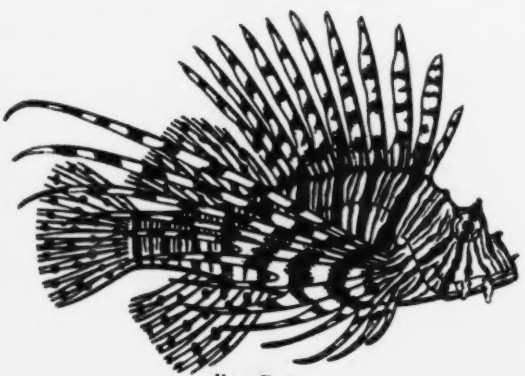
color codes 2

COLORS THAT ADVERTISE

Some fishes have coloration that attracts attention and ADVERTISES A SPECIAL SERVICE.

cleaner wrasse

Small gobies and wrasses of tropical reefs protect themselves by setting up cleaning stations. The distinct coloration and ritualistic behaviors of these small fishes identify them as cleaners. Large fishes visit cleaning stations regularly to be rid of harmful parasites but do not eat the small cleaners because of the helpful service they provide.



lionfish

Some fishes are so well protected with spines, poisons, and armor that their coloration is a WARNING for others to stay away. The lionfish has brightly striped fins with venomous spines that it displays to would-be attackers.

Bright orange and yellow are common warning colors. The Naso tang has bright orange dots near its tail. In the center of each dot is a fearsome blade-like spine. The orange dots warn predators that a bite near this tang's tail could be very painful.

Color plays an important role in SEX AND REPRODUCTION among fishes. The bright pink square on the side of a male anthias is his way of advertising for a mate. Many fishes take on brighter colors during the reproductive cycle and the colors of fishes can change according to their sexual role in the population.

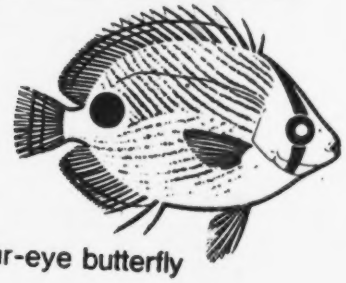
stickleback

Bright colors in TERRITORIAL fishes may increase their visibility and aid them in defending their home range. In their reproductive season, male sticklebacks develop bright red coloration on their bellies that warns intruders to stay away. During this time, the males defend their nests fiercely. The red coloration stays bright until the eggs have hatched and the young fish move out on their own.

New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

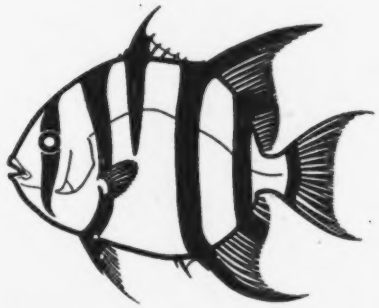
color codes 3

COLORS THAT TELL LIES



four-eye butterfly

Many fishes have color patterns that hide or disguise their eyes. The true eyes of the four-eye butterflyfish are hidden in a band of black. Adding to this disguise are two prominent "FALSE EYES" near the tail. These false eyes may confuse predators. Mistaking them for true eyes, a larger fish is likely to attack the false eye spots and miss the head of the butterflyfish, allowing it to escape in an unexpected direction.



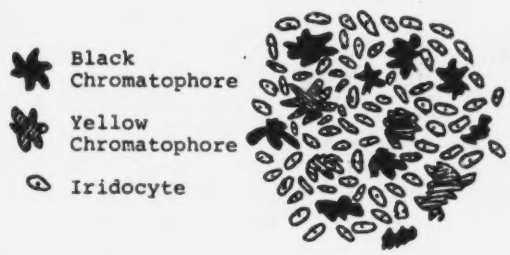
spadefish (adult)

Another way to survive in the aquatic world is to look like something you are not. The dramatically striped adult spadefish is a reef dweller, but the juvenile grows up in shallow waters along the shore. This small fish escapes predation by MIMICing a floating mangrove leaf. Frilly fins and mottled coloration create the disguise. As the fish matures and moves offshore, it takes on the black and white stripes and more efficient swimming shape of the adult.

A more complex form of mimicry can be seen in the sabertooth blenny, or false cleaner wrasse. Though it looks exactly like a true cleaner, this little predator has few satisfied customers. Instead, as larger fishes move in to be cleaned, the sabertooth blenny rushes up and takes painful bites of flesh from their sides with tiny razor-sharp teeth.

CHANGING WARDROBES

Color in fishes is created by two kinds of cells: IRIDOCYTES, cells which reflect light to produce prismatic hues and shiny iridescence, and CHROMATOPHORES, cells containing pigment granules.



In fishes that change colors rapidly, chromatophores are the main players. These cells contain pigment granules that move within the cell. Sometimes they are concentrated into a pinpoint of color. Other times they spread out in a thin sheet to cover a broad area. The pigment in each cell is either red, black or yellow. Other colors are created by combining these three with blues and violet from the iridocytes.

New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

shapes

Body shapes give clues about where fishes live and how they move.

BUILT FOR SPEED

bluefish

The fastest fishes are shaped like submarines. Or rather we should say that submarines are FUSIFORM, shaped like the fastest fishes. The streamlined fusiform shape reduces drag and allows fishes and other objects to move through the water most easily. Many fusiform fishes live in the open ocean and swim continuously, traveling thousands of miles each year. Their tails are forked or crescent shaped, a design that allows maximum speed with minimum effort over long distances. Tuna, swordfish, and mako shark are almost ideal fusiform fishes. Bluefish and jacks are also highly streamlined but not truly fusiform in shape.

ARROWS

barracuda

These hunters ambush their prey. They float motionless until a smaller fish approaches, then lunge out with great speed to seize their victim with long pointed teeth. Their broad powerful tails and elongated arrow-like shape make them some of the fastest fishes. Barracudas can reach speeds of almost 25 miles per hour. But like other arrow-shaped fishes, they cannot maintain such high speeds over long distances. Gars, pike, and pickerel are also arrows.

TWISTS AND TURNS

majestic angelfish

Other fishes have traded speed for maneuverability. Laterally COMPRESSED fishes, flattened from side to side, dart easily around and through corals and aquatic plants. Square or rounded tails propel them forward in quick bursts. Their fins are always active, breaking, steering and guiding them in and out of hiding places with remarkable agility. Their thin flattened bodies and spiny fins make them an awkward mouthful for predators, and viewed head-on, they are so thin they almost seem to disappear.. Coral reef fishes, freshwater angelfishes and moonfish are compressed.

A LITTLE BIT OF EVERYTHING

striped bass

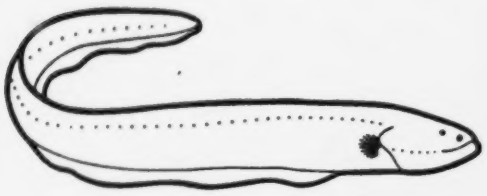
Some fishes need a combination of agility, cruising speed, and quick bursts. It's a hard act, but fishes like trout, salmon, and striped bass make a good show of it. Their bodies show the COMPROMISE: a streamlined shape that is a cross between fusiform and arrow, and is slightly compressed from side to side.

copyright for educational purposes only

oddball shapes

Some fishes have shapes so strange, they do not look like fish at all. Yet these shapes help fishes meet the demands of a variety of aquatic environments.

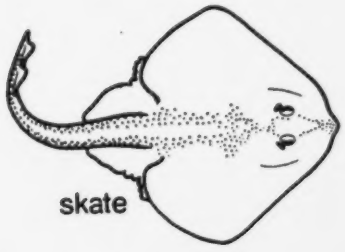
RIBBONS



electric eel

Long snake-like fishes slide easily in and out of tight places, through caves, and around vegetation. The moray eel, like other RIBBON-shaped fishes, undulates its entire body as it swims. The electric eel swims only with its anal fin. Its body must remain rigid to generate the electric field it uses for hunting, protection, and navigation. Wolffish, ocean pout, and loaches are also ribbons.

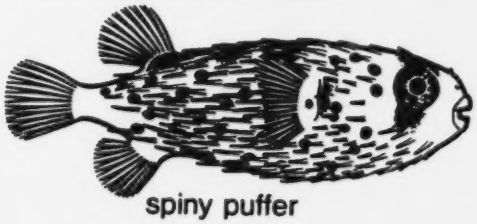
PANCAKES



skate

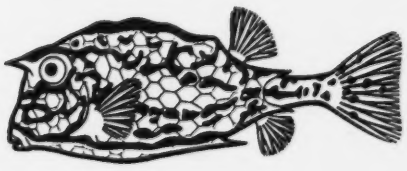
Some fishes have such a low profile they almost seem to be part of the bottom. Most "PANCAKES", flattened bottom dwelling fishes, are camouflaged. Many can change color instantly to blend in with their surroundings. Some bury themselves in the mud or sand to avoid predators. Though most pancakes are slow swimmers, the wing-like pectoral fins of skates and rays allow them a surprisingly hasty escape. Goosefish and flounder are also PANCAKES.

BALLOONS AND BOXES



spiny puffer

Some fishes have such bizarre shapes one wonders how they can swim at all. Cowfishes and trunkfishes have rigid bodies encased in protective armor and use just their fins to get around. Though they won't win any races, these BOX-like fishes are maneuverable. They can swim up, down, even backwards, or may just stop and hover in place like a tiny helicopters with whirling fins.



cowfish

The grossly round pufferfishes also swim slowly but have a special trick for discouraging predators. They inflate like water BALLOONS! Though they may look like easy targets before they inflate, a pufferfish the size of a spiny basketball is too much to swallow, even for the largest predator. Nevertheless, sharks do try to eat puffers and occasionally succeed.

copyright for educational purposes only

it's all in the mouth

The size, shape and orientation of a fish's mouth tell a lot about what it eats. Fish generally eat foods that match the size of their mouths - that is, fishes with big mouths eat big foods and fishes with small mouths feed on smaller items. There are, however, some exceptions to this rule. The world's largest fish, the whale shark, has a huge mouth, yet it feeds on plankton, some of the smallest creatures in the ocean. Huge volumes of water are strained through comb-like gill rakers, to remove these tiny animals. Paddlefish and herring also filter feed with mouths surprisingly larger than the foods they eat.

Amazon catfish

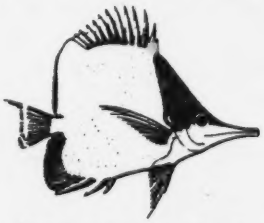
The location of a fish's mouth can also suggest its feeding habits. If its mouth is oriented towards the bottom, the fish is probably a bottom-grubber. Catfishes have mouths on the underside of their heads and fleshy barbels that trail down from their chins to taste for food.

Carp vacuum debris from the bottom with flexible lips. They do not have teeth in their front jaws, but molar-like teeth in their throats grind plants, and crush shells and other tough tidbits.

archerfish

Fishes with upturned mouths are generally surface feeders. Archerfish shoot powerful streams of water into the air, knocking insects out of overhanging vegetation or stopping them mid-flight. The arawana has barbels directed towards the water's surface to detect prey.

Fishes with pointed or knife-edged teeth like sharks and piranha are piscivores, or fish eaters. They move quickly to seize their prey, and have strong stomach acids for digesting food. Fishes with thick fused teeth grind and crush their food. Parrotfishes chew off chunks of coral rock and grind it up to remove living animals and filamentous algae. Marine angelfishes have teeth like a wire brush. They scrape the surface of the reef to remove sponges and tough algae.



long-nose butterfly

Odd-shaped mouths allow some fishes to feed on prey other fishes cannot get to. The long-nose butterflyfish uses its narrow snout to probe for food hidden in cracks and crevices of the coral reef. Some deep sea fishes have jaws that unhinge to swallow prey larger than themselves.

copyright for educational purposes only

more tricks for survival

Some slow swimming predators have a unique way of capturing prey. They go fishing. Goosefish have a fleshy lure that dangles above their huge mouths. Resting motionless on the sea floor, they wait for smaller fish to swim too close, then lunge up to swallow their victims whole. Some deep-sea anglerfishes have lures tipped with a spot of bioluminescence to attract prey in the darkness.

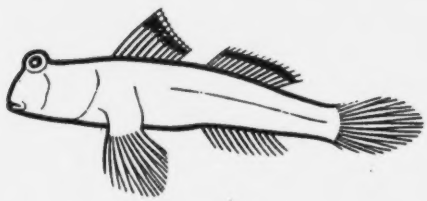
SAFETY IN NUMBERS

Everyone knows that fishes school, but few people realize that schooling has many advantages for survival. Schools are not simply random groups of individuals. The fishes in a school are usually of the same species, same size and same age. These groups offer not only safety in numbers, but also many sets of senses to help detect food. Schools also provide ready access to mates of the same species and reproductive state.

How do schools stay together? Vision plays an important role, but experimental evidence shows that fishes will continue to school even without visual cues. This suggests that the lateral line is also important. With this sixth sense an individual fish uses the vibrations of others in the school to maintain its own position.

Even with hundreds of individuals, the links from fish to fish through eye and lateral line permit a school to behave as if it were a single organism. As a result, schools do not have or need a leader. The individuals move as a tightly knit group in response to environmental cues.

FISHES OUT OF WATER



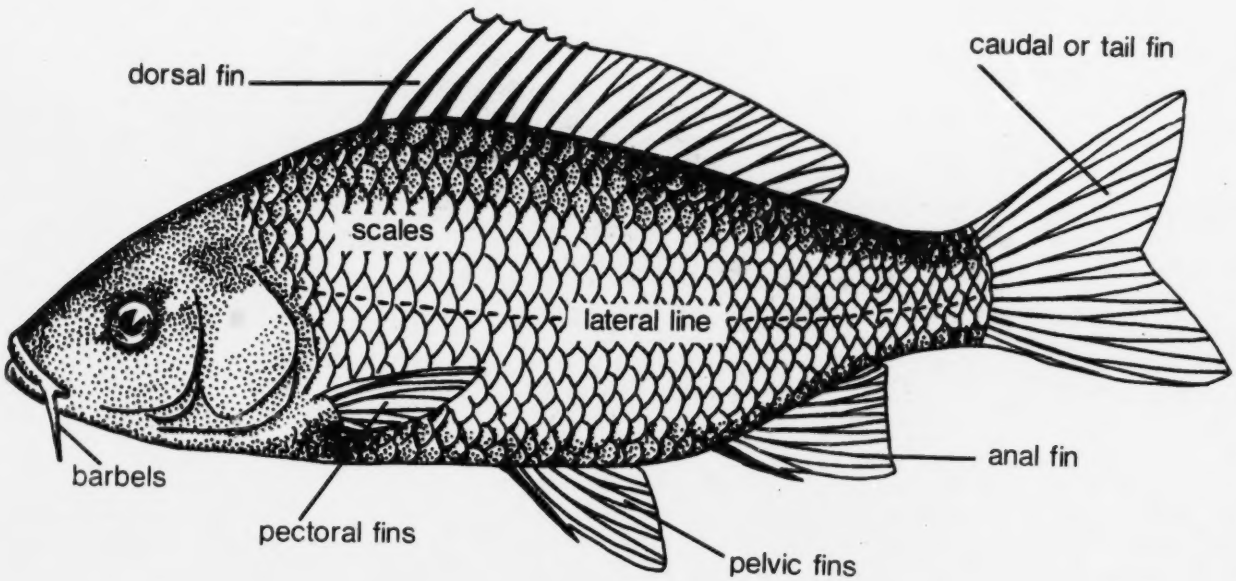
mudskipper

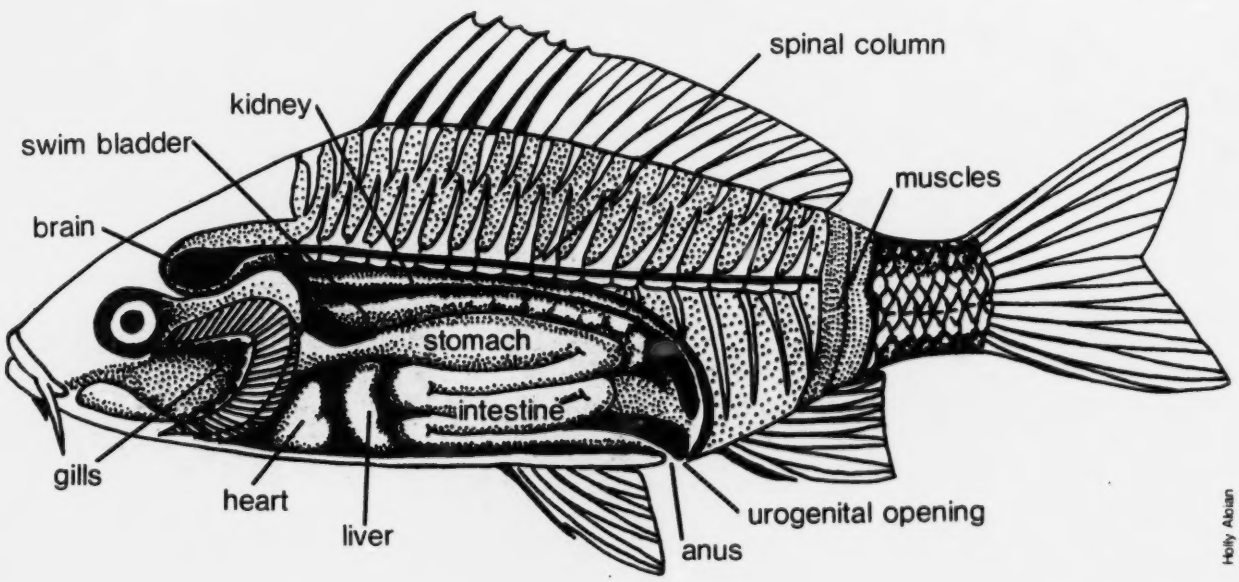
Mudskippers have a surprising habit of hopping out of the water to walk on land or sit among roots in the mangroves. How do they breathe when they are out in the air? These fish carry water with them in the spaces around their gills. The water in the gill chambers allows mudskippers to get plenty of oxygen even when they are completely out of the water. In addition, their throats and mouths have many tiny blood vessels that allow gas exchange if they remain moist. Though mudskippers move in and out of water readily, they never venture too far from puddles and pools. They return often to moisten their eyes and breathing organs .

An even more dramatic fish out of water is the African lungfish. In addition to gills, this fish has lungs that function like ours. In fact, it is so dependent on its lungs it must breathe air or drown. During the dry season, the African lungfish builds a mucous-lined mud cocoon and enters a form of hibernation called estivation. At this time, the lungfish's body processes slow down, it breathes only with its lungs, and stays moist sealed within the protection of its mud cocoon. An estivating lungfish may survive out of the water for months at a time, waiting out drought until heavy rains allow it to return to its aquatic lifestyle.

copyright for educational purposes only

external and internal anatomy





New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

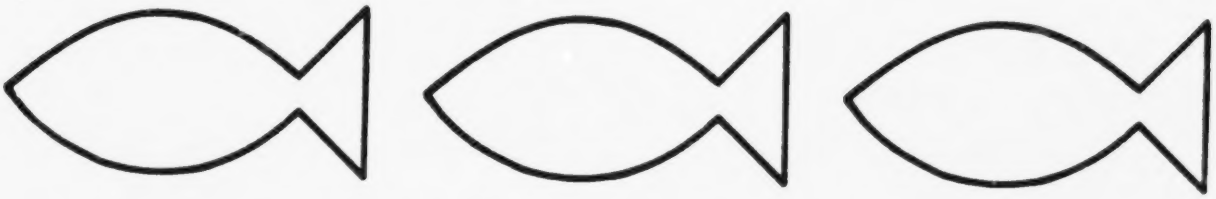
glossary

Adaptation	A physical feature or behavior that helps an organism to survive and reproduce.
Barbels	Fleshy whisker-like sensory organs used to taste and touch.
Behavior	The way an animal acts.
Bioluminescence	Light created by a living organism
Camouflage	Coloration and/or physical features that disguise or hide an animal in its natural habitat.
Countershading	A protective color pattern found in open water animals; dark backs and light bellies.
Fishes	The plural of fish when referring to more than one species. (The plural for one species is just fish.)
Fusiform	Perfectly streamlined shape, like a torpedo.
Habitat	The environment in which an organism is commonly found.
Mangrove	A tropical tree that grows in salt or brackish water. Mangroves are among the most productive plants in the world. These trees form the base of extensive "swamp" ecosystems along coastlines throughout the tropics.
Predator	An animal that hunts another animal for food.
Prey	An animal hunted by another animal for food.
Species	A group of animals or plants that have one or more characteristics in common that distinguish them from similar groups.
Survival requirements	Those things needed to remain alive such as food, shelter, protection.

copyright for educational purposes only

coloration

1. PROTECTIVE COLORATION helps animals survive in their natural habitats. Use these fish shapes to diagram the following kinds of protective coloration:

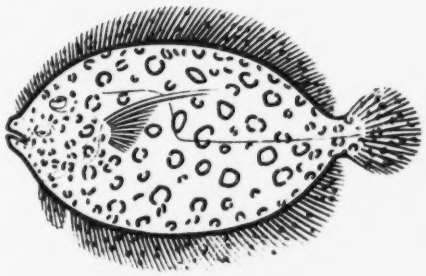


COUNTERSHADING DISRUPTIVE COLORATION FALSE EYE SPOTS

2. What is ADVERTISING COLORATION and how does it help a fish survive?

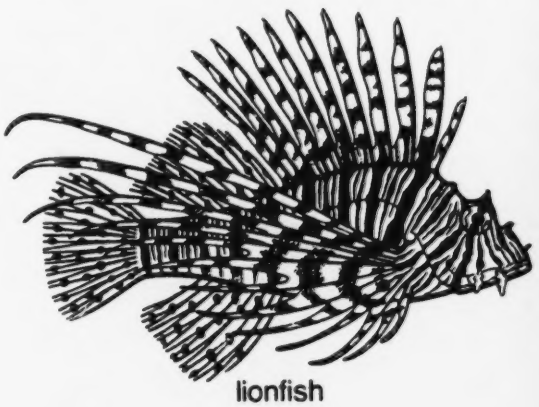
cleaner wrasse

3. What is CAMOUFLAGE and how does it help a fish survive?



peacock flounder

4. What is WARNING COLORATION and how does it help a fish survive?



lionfish

New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

shapes

Choose the term that best describes the shape of each fish shown below:

FUSIFORM PANCAKE ARROW
COMPRESSED RIBBON

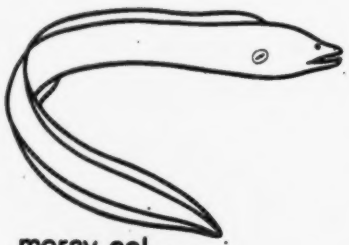
What does shape tell you about how each fish would move and where it might live?

1. Shape: _____

   How does it move and where might it live?

   _____

   _____



moray eel

2. Shape: _____

   How does it move and where might it live?

   _____

   _____

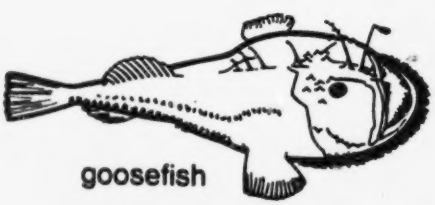
rock beauty

3. Shape: _____

   How does it move and where might it live?

   _____

   _____



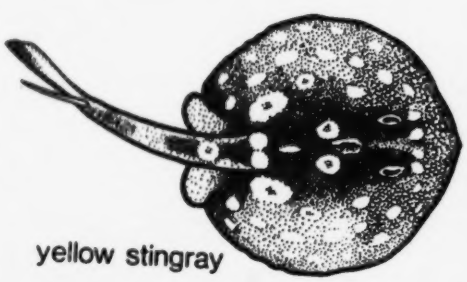
goosefish

4. Shape: _____

   How does it move and where might it live?

   _____

   _____



yellow stingray

5. Shape: _____

   How does it move and where might it live?

   _____

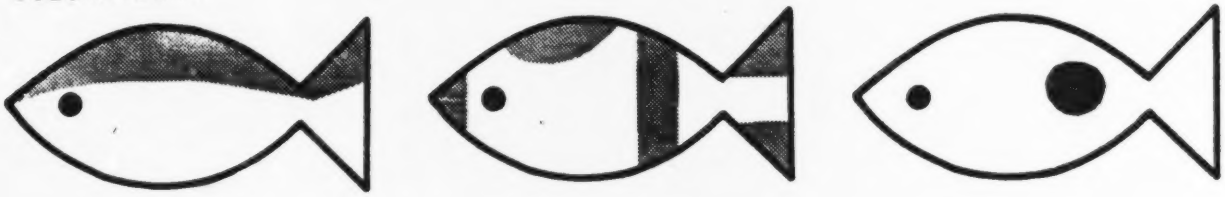
   _____

longnose gar

copyright for educational purposes only

worksheets: answers and discussion

COLORATION:



COUNTERSHADING DISRUPTIVE COLORATION FALSE EYE SPOTS

1. Advertising coloration is usually a bright distinctive pattern that identifies animals to others in a community; it "advertises" a special behavior. Cleaning fishes advertise that they will remove parasites from other fish. Other animals advertise for a mate.

2. Camouflage is a protective coloration that allows animals to blend in perfectly with their natural backgrounds. Many camouflaged animals can also change color.

3. Some animals are so well armed for protection that they are brightly colored to warn other species to stay away from dangerous spines, poisons, etc.

SHAPES:

1. MORAY EEL Shape: Ribbon
   Ribbon-shaped fishes are maneuverable but swim slowly. They are bottom dwellers that live in caves and hide among coral, rocks, or underwater plants.

2. ROCK BEAUTY Shape: Compressed
   These coral reef dwellers make quick short turns. They dart in and out of hiding places in the reef to escape predators.

3. STINGRAY Shape: Pancake
   Like other pancake-shaped fishes, rays and skates are generally bottom-dwellers and slow swimmers. But they can escape quickly if disturbed by using their pectoral fins as wings to rise above the ocean floor. They are camouflaged for protection.

4. MACKEREL Shape: Fusiform
   Fusiform fishes are fast, efficient swimmers. Most are open ocean species. Some swim continuously throughout their lives.

5. LONGNOSE GAR Shape: Arrow
   Arrow-shaped fishes are ambush experts. They may float motionless for long periods of time, then lunge out with lightning speed if predators or prey swim near.

copyright for educational purposes only

2

trip activities

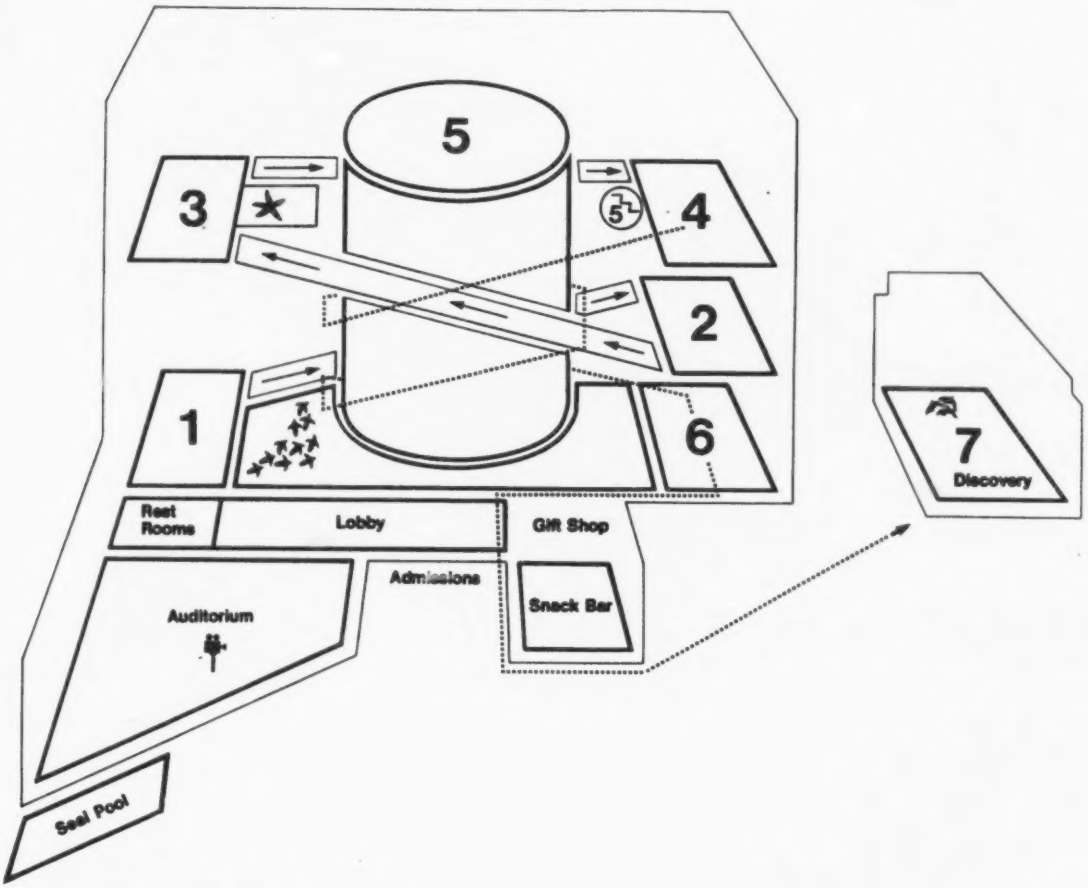
field-trip planning

A unique look at "the world of water" awaits your students when they visit the New England Aquarium. To help your trip run smoothly, keep in mind the following:

- Be sure your students are adequately supervised. One chaperone is admitted FREE for every 10 students.
- Remember the Aquarium's exhibit galleries are dimly lit, giving the illusion of entering an underwater world. The exhibit tanks themselves are well-lit.
- Students will receive handstamps as they enter. These will allow them to attend the dolphin and sea lion show, and re-enter the main building.
- The Aquarium is a self-touring museum. Students should use the graphics, labels and audio tapes accompanying the exhibits to learn more about the organisms and habitats on display.
- Educational programs, like FISHTALES, take place in the Aquarium auditorium. Your students will be paged to the auditorium 10 minutes before the show begins. Please arrive on time as several schools may be scheduled to attend the same program. RESERVATIONS are required.
- The dolphin and sea lion show is held on the ship DISCOVERY. To get to the DISCOVERY, you must exit through the front doors of the main building. Doors open 15 minutes before show-time.
- The "Edge of the Sea" exhibit is on the third level of the building. Here students will have the opportunity to pick up live seashore animals. Aquarium staff will be available to answer questions. Please remind students that live animals must be handled with care.
- Aquarium volunteers, wearing blue smocks, are available throughout the building to answer your questions and talk with your students.
- If possible, try to schedule your visit during the FALL or WINTER months. Springtime is the school field trip season and your students may be sharing the exhibit areas with many others during this time.

copyright for educational purposes only

New England Aquarium



1 Special Exhibit
2 Temperate Marine Gallery
3 Freshwater "Edge of the Sea" / Tidepool
4 Northern Waters of the World / Harrington Gallery
5 Top of the Giant Ocean Tank / (5) Stairs
6 Tropical Marine Gallery
7 Discovery / Marine Mammal Show

NOTE:
To all the exhibits in the main building follow a one-way route along straight ramps to the top of the building and descend to the first floor along the spiral ramp of the Giant Ocean Tank.

New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

reading fishes 1

The color, shape and behavior of a fish tell stories about its lifestyle. Test your skills at "reading" these fishes.

****

EXHIBIT: Isles of Shoals NORTHERN WATERS GALLERY

What is this fish doing?

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:

Name: Goosefish
Scientific Name:

****

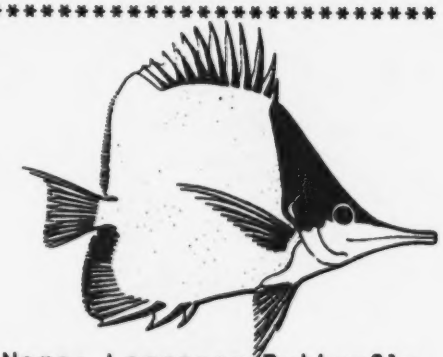
EXHIBIT: Pacific Reef TROPICAL GALLERY

What is this fish doing:

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:



Name: Longnose Butterfly
Scientific name:

****

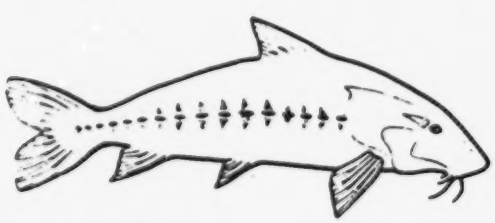
EXHIBIT: Amazon River FRESHWATER GALLERY

What is this fish doing:

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:



Name: Amazon Catfish
Scientific name:

New England Aquarium Education Department Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

reading fishes 2

EXHIBIT: Mangrove Swamp TEMPERATE GALLERY

What is this fish doing:

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:

Name: Foureyes
Scientific name: _____

****

EXHIBIT: Caribbean Reef GIANT OCEAN TANK

What is this fish doing:

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:

Name: Smalltooth Sawfish
Scientific name: _____

****

CHOOSE A FISH YOU WANT TO READ.

EXHIBIT: _____

What is this fish doing:

Describe its natural habitat:

How do you think this fish uses color, shape and behavior to find food:

To protect itself:

Name: _____
Scientific name: _____

copyright for educational purposes only

reading fishes: answers and discussion 1

READING FISHES is an activity that encourages students to look closely at fishes and draw conclusions about fish lifestyles and their adaptations for survival. While readings in this curriculum focus on the importance of shape, color, and behavior individually, you should emphasize in classroom discussions that survival depends on not one, but all of these characteristics.

As your students complete this exercise, direct them to "read" each fish as a whole. Encourage them to make connections between the color, shape, behavior and habitat of each species. As they become more skilled at "reading" fishes, students will understand that color, shape and behavior are all just chapters that make up the whole book on fish survival.

In evaluating your students' performance on this activity keep in mind that the process of observation may be new to many of them. Developing good observation skills and learning to make connections between classroom work and new information are as important, if not more important, than the "answers" students bring back. Discussions that follow-up field-trip work will help students interpret their observations and and draw accurate conclusions about the fishes they have "read".

Name: GOOSEFISH, also All-Mouth, Mouth Almighty, Monkfish
Behavior: Sits quietly and looks like a piece of the ocean floor. Moves about on leg-like pectoral fins. Yawns occasionally.
Habitat: Sandy or muddy bottoms along beaches, and in estuaries.
Food: Uses camouflage to hide from and ambush prey; "fishing" rod and lure on top of head attract small fish. Will also lunge upwards to engulf a large fish or duck in its huge mouth.
Protection: Uses camouflage and buries in sand to hide from predators; fleshy flaps of skin around the jaw and edges of body help break up the outline of the fish and prevent it from casting a tell-tale shadow.

Name: LONGNOSE BUTTERFLY
Behavior: Darts in and out of corals, hides in cracks and crevices, probes for food, interacts with other fishes.
Habitat: Pacific coral reefs, many caves and crevices.
Feeding: Uses long snout to probe in cracks and crevices of the reef for tiny crustaceans and other invertebrates.
Protection: Compressed body shape allows it to dart in and out of hiding places in the reef. Disruptive coloration breaks up the body shape and may provide camouflage among corals; false eye-spots may confuse attackers. Thin body and spiny fins are unappetizing.

copyright for educational purposes only

reading fishes: answers and discussion 2

Name: AMAZON CATFISH
Behavior: Swims slowly over bottom; probes in gravel with barbels in search of food.
Habitat: Rivers in the Amazon basin, waters are muddy and dark; prefers bottom waters.
Feeding: Uses barbels and sensitive mouth to locate small animals hidden in the river bottom. Though it is adapted for feeding off the bottom, this catfish and others are as willing to take food mid-water or from the surface when it is available there..
Protection: Bony armor, huge spines on dorsal and pectoral fins. Dark color offers camouflage in muddy river waters. Size- adults are larger than most fishes that might eat them.

Name: FOUREYES
Behavior: Swims at the water's surface; looks above and below the water simultaneously; frequently submerges head to moisten eyes.
Habitat: Mangrove swamps of Central and South America. (These are rich and diverse ecosystems; animal and plant communities are found everywhere- in mangrove roots, in swamp shallows, and in the tree canopy overhanging the water. Predators are abundant.)
Feeding: Catches insects and other foods that fall into the water.
Protection: Ability to see above and below the water helps protect against ambush by flying, wading, or swimming predators. Quick and agile; slender body moves easily through mangrove roots and aquatic vegetation.

Name: SMALLTOOTH SAWFISH
Behavior: Swims midwater like a shark, buries in the sand like a ray. Spiracles on top of head bring water to gills which are located on the underside of the body; they open and close as the fish breathes.
Habitat: Sandy areas in warm, shallow waters, occasionally visit coral reefs.
Feeding: Swings head from side to side to stun and injure individuals as it swims through schools of fish; grubs with saw in mud and sand to stir up crabs, shrimp, and other bottom dwellers.
Protection: Sharp tooth-lined saw; size; countershading.

Name: CHOOSE A FISH YOU WANT TO READ
With careful observation, students should be able to draw intelligent conclusions about the fishes they choose to read themselves. As a follow-up activitiy, suggest that students research each fish and compare the findings of scientists with their own. They may be surprised to discover that many of the predictions they made are accurate.

The worksheet, ANIMAL BEHAVIOR, is an expanded version of the final question on the READING FISHES worksheet. For suggestions on preparing students for this activity and evaluating their performance, please refer to the information above.

copyright for educational purposes only

lab exercise: animal behavior

Biologists attempt to describe the behavior of animals in an effort to understand how they live. In this exercise you will spend a certain amount of time observing live animals to determine aspects of their behavior.

Choose an animal and observe it closely for 5 minutes. Record the following information:

Common name: _____

Scientific name: _____

Natural habitat: _____

Color(s): _____

Approximate size: _____

sketch

Unusual features: _____

_____

Special adaptations for finding food:

_____

Special adaptations for defense:

_____

Describe the animal's movements, interactions with tank mates, and other behaviors:

_____

_____

_____

_____

_____

_____

copyright for educational purposes only

3

post-trip activities

activities

CLASSROOM AQUARIUM	Set up a freshwater aquarium in the classroom. Have students observe fishes and keep a daily log of feeding behaviors, interactions, growth, etc.
FISH DISSECTION	Obtain fish for dissection from a fish store or biological supply house. Study external anatomy: scales, fins, gills, lateral line, etc. Compare internal and external anatomy with that of other vertebrates.
RESEARCH	Research environments represented at the New England Aquarium - Coral Reef, Amazon River, Mangrove Swamp, Boston Harbor. What animals live in these areas and how are they dependent on their habitats? As humans alter or destroy these habitats, how would it affect the animals that live there?
DESIGN A FISH	Choose fin, tail, and body shapes to create fishes. Design fast fishes, slow fishes, or the strangest fishes imaginable. Where would these fishes live and how would their body shapes help them to survive?
CREATIVE HABITATS	Create a habitat and describe animals with adaptations to live there. For example: invent an animal that could live in orange Jello, eat food in tin cans, and would come out only at night.
ECOSYSTEMS	Have students "diagram" an ecosystem. Animals and plants may be classified according to their position in the food chain, their preferred habitat within the ecosystem, or their role in the biological community. Discuss the adaptations of each for survival within this ecosystem.
HUMAN SURVIVAL	How are humans adapted to their habitats? How do humans modify their environments to survive? What kinds of "adaptations" could human bodies develop in the next 1,000 years to survive noise pollution, smog, overcrowding, etc.?

copyright for educational purposes only

bibliography 1

Axelrod, Dr. Herbert and Dr. Leonard P. Schultz: Handbook of Tropical Aquarium Fishes, T.F.H. Publications, Inc, 1983.

Bigelow and Schroeder: Fishes of the Western North Atlantic, U.S. Government Printing Office, Washington, D.C., 1953. A classic.

Bond, Carl E.: Biology of Fishes, W.B. Saunders Company, Philadelphia, 1979.

Bone, Q and N.B. Marshall: Biology of Fishes, Chapman & Hall, NY, 1982.

Cousteau, Jacques-Yves: The Ocean World of Jacques Cousteau, Danbury Press, CT, 1975. A 20 volume reference set.

Grizmek's Animal Life Encyclopedia: Fishes I and II, Van Nostrand Reinhold, 1972.

Ellis, Richard: The Book of Sharks, Grosset & Dunlap, NY, 1976.

Marshall, N.B.: The Life of Fishes, Weidenfeld and Nicolson, London, 1965.

Marshall, N.B.: Explorations in the Life of Fishes, Harvard University Press, Cambridge, MA, 1971.

Moyle, Peter B. & Joseph J. Cech, Jr.: Fishes, an introduction to icthyology, Prentice-Hall, Inc., NJ, 1982.

Niesen, Thomas M.: The Marine Biology Coloring Book, Barnes and Noble Books, NY, 1982.

Norman, J.R.: A History of Fishes, Ernest Benn, Limited, London, 1975.

Sarnoff, Jane and Reynold Ruffins, A Great Aquarium Book, Scribner, NY, 1977. A guide to getting started with freshwater species.

Simon, Seymour: What do you want to know about guppies?, Four Winds Press, NY, 1977. All the basics you need for setting-up a freshwater aquarium and studying guppy behavior

Time-Life: Fishes of Lakes, Rivers, and Oceans, Time-Life Films, Inc., NY, 1978. from the Wild, Wild World of Animals Television Series; other titles include- Dangerous Sea Creatures, Life in the Coral Reef, and Island Life.

Tinbergen, Niko: Animal Behavior, Time-Life Books, NY, 1965. from the Life Nature Library; other titles include- The Fishes, The Sea, The Reptiles, Evolution, Ecology.

copyright for educational purposes only

bibliography 2

Wheeler, Alwyne: Fishes of the World, an Illustrated Dictionary, MacMillan Publishing Company, Inc., NY, 1975.

Other Publications:

Current: The Journal of Marine Education, publication of the National Marine Education Association. Free with membership; annual dues $15. NMEA, Box 666, Narragansett, RI 02882.

Flotsam and Jetsam, newsletter of the Massachusetts Marine Educators. Free with membership; annual dues $5. For more information contact: Barbara Passero, Editor, Flotsam and Jetsam, Suffolk University, Department of Biology, Boston, MA 02114.

National Geographic Society Magazine, P.O. Box 2330, Washington, DC 20036. Annual subscription only $15.

Audio-visual and Print Resources:

Educational Images Ltd., P.O. Box 367, Lyons Falls, NY 13368. Distributes filmstrips, slide sets and computer software. Slide set titles include- Fishes and their Morphological Diversity, Venomous and Poisonous Marine Animals, Behavioral Significance of Coloration in Reef Fishes, etc.

National Geographic Society, Educational Services, Washington, DC 20036. Educational Services Catalog includes filmstrips, multimedia kits and books; also Film and Video Catalog.

National Marine Fisheries Service and NOAA, Superintendant of Documents, Government Printing Office, Washington, D.C. 20402. Large charts featuring fishes of the North Atlantic, North Pacific, Gulf of Mexico, Great Lakes, etc. These charts are printed on plasticized paper and reasonably priced. U.S. goverment offices also offer FREE brochures and pamphlets on fisheries and research. Contact them for current titles and poster prices.

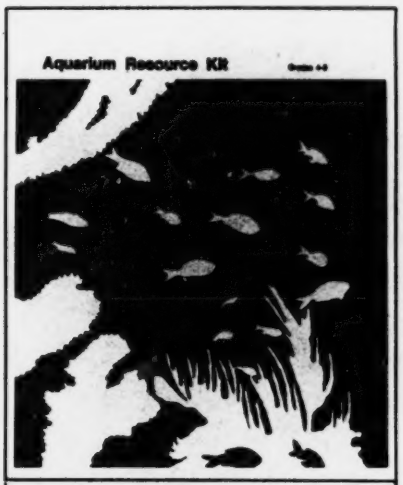
New England Aquarium Gift Shop, Central Wharf, Boston, Ma 02110. Posters, postcards and books are available. Write for a catalog of gift shop items, or call for information on items in stock.

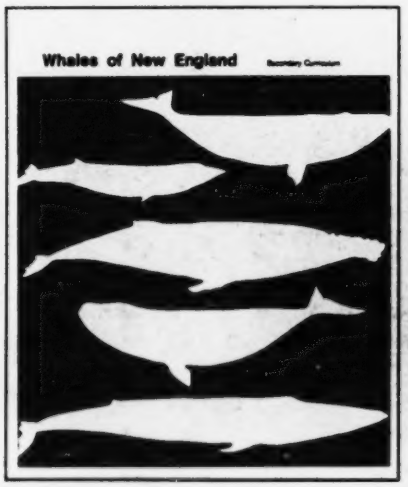
copyright for educational purposes only

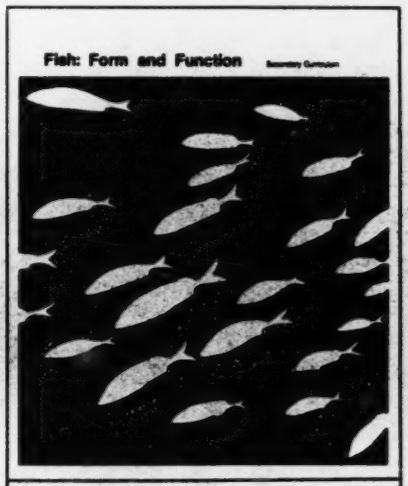
special thanks

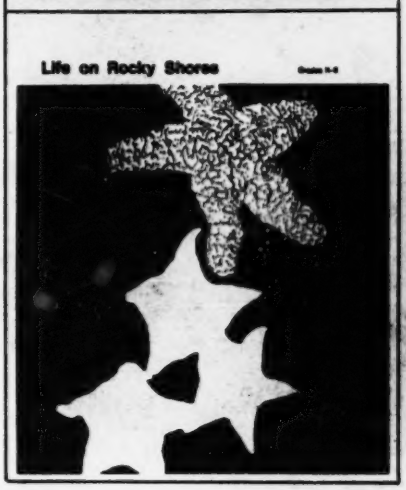
The New England Aquarium would like to thank the following donors for their generous support of our exhibits and educational programs:

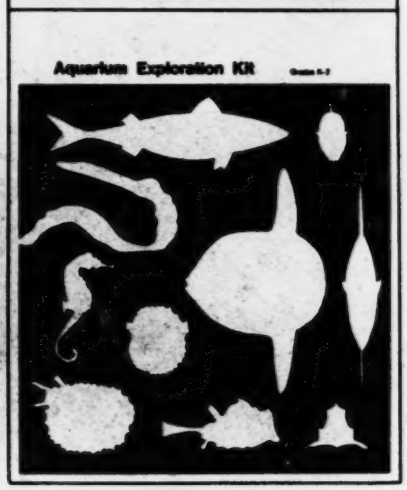
Phillip Morris, Inc.
H.K. Porter
Alexander & Alexander
Harold Cabot & Co.
First American Bank for Savings
Knapp-King Size
New England Electric System
J.F. White Contracting Co.











New England Aquarium **Education Department** Central Wharf, Boston MA (617) 742 - 8830
copyright for educational purposes only

This nonprofit organization was created to establish, maintain and operate a New England public aquarium. Contributions are deductible under federal income tax laws.